

CLAIMS

1. A method of imparting motion to a fluid, said method comprising,
providing an acoustic source adapted to generate an acoustic field,
providing said acoustic field to a fluid, and
selectively positioning at least one nucleation feature adapted to interact with said
acoustic field to impart said motion to said fluid.
2. The method of claim 1 further comprising, interacting said at least one nucleation feature
with said acoustic energy in a focal zone of said acoustic source
3. The method of claim 1, wherein said step of providing said acoustic field further
comprises, providing an unfocussed acoustic field.
4. The method of claim 1, wherein said fluid contacts a first surface and said method further
comprises positioning said at least one nucleation feature at said first surface.
5. The method of claim 4, wherein said first surface is a surface of a microconduit.
6. The method of claim 4, wherein said first surface is a surface of a microchamber.
7. The method of claim 4, wherein said first surface is a surface containing one or more
active sites.
8. The method of claim 4, wherein said at least one nucleation feature includes at least one
of a pit, crevice, defect, scratch, groove and ridge in said first surface.
9. The method of claim 4, wherein said at least one nucleation feature includes at least one
of a hydrophobicity, wettability, and surface energy characteristic of said first surface.
10. The method of claim 4, wherein said at least one nucleation feature includes a plurality of
nucleation features forming a texture.
11. The method of claim 4, wherein said nucleation feature includes an electrochemically or
chemically active location.
12. The method of claim 1, wherein said fluid has a volume between about 0.1 pl and about
10 ml.
13. The method of claim 1, wherein said fluid has a volume between about 10 nl and about
100 ml.

- 1 14. The method of claim 1, wherein said at least one nucleation feature is suspended in said
2 fluid.
- 1 15. The method of claim 1, wherein said fluid is contained in a microchamber.
- 1 16. The method of claim 1, wherein said fluid is contained in a microconduit.
- 1 17. The method of claim 14, wherein said at least one nucleation feature includes at least one
2 of a bead, resin, microsphere and particle.
- 1 18. The method of claim 1, wherein said step of providing said acoustic field further
2 comprises, providing an acoustic waveform having a frequency between about 10 kHz and about
3 100 MHz.
- 1 19. The method of claim 1, wherein said step of providing said acoustic field further
2 comprises, providing an acoustic waveform having a frequency between about 100 kHz and
3 about 10 MHz.
- 1 20. The method of claim 1, wherein said step of providing said acoustic field further
2 comprises, providing said acoustic field at a power selected to promote bubble formation at said
3 at least one nucleation feature.
- 1 21. The method of claim 1, wherein said step of providing said acoustic field further
2 comprises, providing said acoustic field at at least one of a duty cycle, duty cycles per burst,
3 amplitude, frequency, time variations in frequency, and time variations in amplitude selected to
4 control bubble formation at said at least one nucleation feature.
- 1 22. The method of claim 1, wherein said acoustic field interacts with said at least one
2 nucleation feature to promote bubble formation in said fluid, and said method further comprises
3 sensing cavitation and employing said sensed cavitation in a feedback loop to control said bubble
4 formation.
- 1 23. The method of claim 1, wherein said motion imparted to said fluid is of sufficient
2 magnitude to cause a mixing action in said fluid.
- 1 24. The method of claim 1, wherein fluid is contained in a microdevice, and said step of
2 providing said acoustic source further comprises, providing said acoustic source as a component
3 of said microdevice.
- 1 25. The method of claim 24, wherein said step of providing said acoustic source further
2 comprises positioning said acoustic source in direct contact with said fluid.

1 26. The method of claim 1, wherein said fluid is contained in a microdevice, and said step of
2 providing said acoustic source further comprises, attaching said acoustic source to an outer
3 surface of said microdevice.

1 27. The method of claim 1, wherein said step of providing said acoustic field further
2 comprises, providing said acoustic field with selected characteristics to promote mixing of only
3 that portion of said fluid that is proximate to said at least one nucleation feature.

1 28. The method of claim 1 further comprising,
2 positioning said at least one nucleation feature relative to an active site, and said step of
3 providing said acoustic field further comprises, providing said acoustic field with selected
4 characteristics to promote mixing of a portion of said fluid proximate to said active site.

1 29. The method of claim 1 further comprising, moving relative positions between said
2 acoustic source and said at least one nucleation feature to alter said motion imparted to said fluid.

1 30. The method of claim 1, wherein said step of providing at least one nucleation feature
2 further comprises, positioning at least one nucleation feature relative to each of an array of active
3 sites to impart a particular motion to fluid proximate to each of said array of active sites.

1 31. The method of claim 1, wherein said step of providing an acoustic source further
2 comprises providing a plurality of acoustic sources.

1 32. The method of claim 1, wherein said step of selectively positioning said at least one
2 nucleation feature further comprises positioning said at least one nucleation feature to effect a
3 direction of said motion imparted to said fluid.

1 33. The method of claim 5, wherein said step of selectively locating said nucleation feature
2 further comprises, locating said at least one nucleation feature on or in at least said first surface,
3 and said step of providing said acoustic field to said fluid further comprises providing said
4 acoustic field to said fluid with selected characteristics to form a bubble proximate to said
5 nucleation feature to impair fluid flow in said microconduit.

1 34. The method of claim 36 further comprising ceasing to provide said acoustic field to cause
2 said bubble to dissipate to remove said impairment to fluid flow.

1 35. The method of claim 1, wherein said step of selectively positioning at least one nucleation
2 feature further comprises selectively positioning a plurality of nucleation features, and said

method further comprises varying a relative position between said acoustic source and said plurality of nucleation features to time vary said motion imparted to said fluid.

36. The method of claim 1, wherein said fluid is contained in a microvessel having a plurality of regions and contains a constituent initially located in a first of said plurality of regions, and said step of providing said acoustic field further comprises, providing said acoustic field selectively to each of said plurality of regions to cause said constituent to flow from said first region through a remainder of said plurality of regions.

37. The method of claim 36, wherein said constituent is a biological sample.

38. A method of imparting motion to a fluid, said method comprising, providing an acoustic source adapted to generate an acoustic field, and selectively directing said acoustic field to at least one nucleation feature located relative to said fluid to impart said motion to said fluid.

39. The method of claim 38, wherein said step of directing said acoustic field further comprises, focussing said acoustic field to said at least one nucleation feature.

40. The method of claim 38, wherein said step of directing said acoustic field further comprises, adjusting a relative position between said acoustic source and said at least one nucleation feature to bring said at least one nucleation feature within a focal zone of said acoustic source.

41. The method of claim 38, wherein said step of directing said acoustic field further comprises, employing block to block said acoustic field from locations in said fluid.

42. The method of claim 38, wherein said step of directing said acoustic field further comprises, employing reflectors to direct said acoustic field to said at least one nucleation feature.

43. The method of claim 38, wherein said fluid contacts a first surface, and said first surface includes said at least one nucleation feature.

44. The method of claim 43, wherein said first surface is a surface of a microconduit.

45. The method of claim 43, wherein said first surface is a surface of a microchamber.

46. The method of claim 43, wherein said first surface is a surface containing one or more active sites.

1 47. The method of claim 43, wherein said at least one nucleation feature includes at least one
2 of a pit, crevice, defect, scratch, groove and ridge in said first surface.

1 48. The method of claim 43, wherein said at least one nucleation feature includes at least one
2 of a hydrophobicity, wettability, and surface energy characteristic of said first surface.

1 49. The method of claim 43, wherein said at least one nucleation feature includes a plurality
2 of nucleation features forming a texture.

1 50. The method of claim 43, wherein said at least one nucleation feature includes an
2 electrochemically or chemically active.

1 51. The method of claim 43, wherein said fluid has a volume between about 0.1 pl and about
2 10 ml.

1 52. The method of claim 43, wherein said fluid has a volume between about 10 pl and about
2 100 nl.

1 53. The method of claim 38, wherein said at least one nucleation feature is suspended in said
2 fluid.

1 54. The method of claim 38, wherein said fluid is contained in a microchamber.

1 55. The method of claim 38, wherein said fluid is contained in a microconduit.

1 56. The method of claim 53, wherein said nucleation feature includes at least one of a bead,
2 resin, microsphere and particle.

1 57. The method of claim 38, wherein said step of directing said acoustic field further
2 comprises, providing an acoustic waveform having a frequency between about 10 kHz and about
3 100 MHz.

1 58. The method of claim 38, wherein said step of directing said acoustic field further
2 comprises, providing an acoustic waveform having a frequency between about 100 kHz and
3 about 10 MHz.

1 59. The method of claim 38, wherein said step of directing said acoustic field further
2 comprises, providing said acoustic field at a power selected to promote bubble formation at said
3 at least one nucleation feature.

1 60. The method of claim 38, wherein said step of directing said acoustic field further
2 comprises, providing said acoustic field at at least one of a duty cycle, duty cycles per burst,

amplitude, frequency, time variations in frequency, and time variations in amplitude selected to control cavitation of a bubble at said at least one nucleation feature.

61. The method of claim 38, wherein said step of directing said acoustic field further comprises providing said acoustic field to cause stable cavitation of a bubble at said at least one nucleation feature.

62. The method of claim 38, wherein said acoustic field interacts with said at least one nucleation feature to promote bubble formation in said fluid, and said method further comprises sensing cavitation and employing said sensed cavitation in a feedback loop to control said bubble formation.

63. The method of claim 38, wherein said motion imparted to said fluid is of sufficient magnitude to cause a mixing action in said fluid.

64. The method of claim 38, wherein fluid is contained in a microdevice, and said step of providing said acoustic source further comprises, providing said acoustic source as a component of said microdevice.

65. The method of claim 64, wherein said step of providing said acoustic source further comprises positioning said acoustic source in direct contact with said fluid.

66. The method of claim 38, wherein said fluid is contained in a microdevice, and said step of providing said acoustic source further comprises, attaching said acoustic source to an outer surface of said microdevice.

67. The method of claim 38, wherein said step of directing said acoustic field further comprises, providing said acoustic field with selected characteristics to promote mixing of only that portion of said fluid that is proximate to said at least one nucleation feature.

68. The method of claim 38 further comprising,
positioning said at least one nucleation feature relative to an active site, and said step of providing said acoustic field further comprises, providing said acoustic field with selected characteristics to promote mixing of a portion of said fluid proximate to said active site.

69. The method of claim 38 further comprising, moving relative positions between said acoustic source and said at least one nucleation feature to alter said motion imparted to said fluid.

70. The method of claim 38, wherein said at least one nucleation feature is located relative to each of an array of active sites, and said step of directing said acoustic field further comprises,

directing said acoustic field to array of active sites to impart a particular motion to fluid proximate to each of said array of active sites.

71. The method of claim 38, wherein said step of providing said acoustic source further comprises providing a plurality of acoustic sources.

72. The method of claim 38, wherein said at least one nucleation site comprises a plurality of nucleation sites, and said step of directing said acoustic field further comprising, selectively directing said acoustic field at particular ones of said plurality of nucleation features to effect a direction of said motion imparted to said fluid.

73. The method of claim 38, wherein said step of directing said acoustic field further comprises selectively directing said acoustic field to said at least one nucleation feature included in said first surface with selected characteristics to form a bubble proximate to said nucleation feature to impair fluid flow in said microconduit.

74. The method of claim 73, further comprising ceasing to provide said acoustic field to cause said bubble to dissipate to remove said impairment to fluid flow.

75. The method of claim 38, wherein said at least one nucleation feature includes a plurality of nucleation features, and said step of directing said acoustic field further comprises, time varying a relative position between said acoustic field and said plurality of nucleation features to time vary said motion imparted to said fluid.

76. The method of claim 38, wherein said fluid is contained in a microvessel having a plurality of regions and contains a constituent initially located in a first of said plurality of regions, and said step of providing said acoustic field further comprises, providing said acoustic field selectively to each of said plurality of regions to cause said constituent to flow from said first region through a remainder of said plurality of regions.

77. The method of claim 763, wherein said constituent is a biological sample.

78. An apparatus for imparting motion to a fluid, said apparatus comprising,
an acoustic source adapted to provide an acoustic field,
a controller adapted to control operation of said acoustic source,
at least one nucleation feature, selectively located and adapted to interact with said acoustic field to impart said motion to said fluid.

1 79. The apparatus of claim 78, wherein said acoustic source is further adapted to provide a
2 focussed acoustic field.

1 80. The apparatus of claim 78, wherein said fluid contacts a first surface and said at least one
2 nucleation feature is selectively positioned at said first surface.

1 81. The apparatus of claim 80, wherein said first surface is a surface of a microconduit.

1 82. The apparatus of claim 80, wherein said first surface is a surface of a microchamber.

1 83. The apparatus of claim 80, wherein said first surface is a surface containing one or more
2 active sites.

1 84. The apparatus of claim 80, wherein said at least one nucleation feature includes at least
2 one of a pit, crevice, defect, scratch, groove and ridge in said first surface.

1 85. The apparatus of claim 80, wherein said at least one nucleation feature includes at least
2 one of a hydrophobicity, wettability, and surface energy characteristic of said first surface.

1 86. The apparatus of claim 80, wherein said at least one nucleation feature includes a fabric.

1 87. The apparatus of claim 80, wherein said at least one nucleation feature includes an
2 electrochemically active site.

1 88. The apparatus of claim 80, wherein said nucleation feature includes a distribution of
2 impurities on said first surface.

1 89. The apparatus of claim 80, wherein said nucleation feature includes a distribution of
2 impurities in said first surface.

1 90. The apparatus of claim 78, wherein said nucleation feature is suspended in said fluid.

1 91. The apparatus of claim 78, wherein said fluid is contained in a microchamber.

1 92. The apparatus of claim 78, wherein said fluid is contained in a microconduit.

1 93. The apparatus of claim 90, wherein said at least one nucleation feature includes at least
2 one of a bead, resin, microsphere and particle.

1 94. The apparatus of claim 78, wherein said acoustic source is further adapted to provide an
2 acoustic waveform having a frequency between about 10 kHz and about 100 MHz.

1 95. The apparatus of claim 78, wherein said acoustic source is further adapted to provide an
2 acoustic waveform having a frequency between about 100 kHz and about 10 MHz.

1 96. The apparatus of claim 78, wherein said acoustic source is further adapted to provide said
2 acoustic field at a power selected to promote bubble formation at said at least one nucleation
3 feature.

1 97. The apparatus of claim 78, wherein said acoustic source is further adapted to provide said
2 acoustic field at at least one of a duty cycle, duty cycles per burst, amplitude, frequency, time
3 variations in frequency, and time variations in amplitude selected to control cavitation of a
4 bubble at said at least one nucleation feature.

1 98. The apparatus of claim 78, wherein said acoustic field interacts with said at least one
2 nucleation feature to promote bubble formation in said fluid, and said apparatus further
3 comprises, cavitation sensors adapted to sense cavitation, and provide a feedback signal to said
4 controller, and said controller is further adapted to employ said feedback signal to control said
5 bubble formation.

1 99. The apparatus of claim 78, wherein said motion imparted to said fluid is of sufficient
2 magnitude to cause a mixing action in said fluid.

1 100. The apparatus of claim 78, wherein fluid is contained in a microdevice, and said acoustic
2 source is a component of said microdevice.

1 101. The apparatus of claim 100, wherein said acoustic source is positioned in direct contact
2 with said fluid.

1 102. The apparatus of claim 78, wherein said fluid is contained in a microdevice, and said
2 acoustic source is attached to an outer surface of said microdevice.

1 103. The apparatus of claim 78, wherein said acoustic source is further adapted to provide said
2 acoustic field with selected characteristics to promote mixing of only that portion of said fluid
3 that is proximate to said at least one nucleation feature.

1 104. The apparatus of claim 78, wherein said at least one nucleation feature is selectively
2 positioned relative to an active site, and said acoustic source is further adapted to provide said
3 acoustic field with selected characteristics to promote mixing of a portion of said fluid proximate
4 to said active site.

1 105. The apparatus of claim 78 further comprising, a positioning mechanism adapted to move
2 relative positions between said acoustic source and said at least one nucleation feature to alter
3 said motion imparted to said fluid.

1 106. The apparatus of claim 78, wherein said at least one nucleation feature is selectively
2 positioned relative to each of an array of active sites to impart a particular motion to fluid
3 proximate to each of said array of active sites.

1 107. The apparatus of claim 78, wherein said acoustic source further comprises a plurality of
2 acoustic sources.

1 108. The apparatus of claim 78, wherein said at least one nucleation feature is positioned to
2 effect a direction of said motion imparted to said fluid.

1 109. The apparatus of claim 78, wherein said at least one nucleation feature is located at at
2 least said first surface, and said acoustic source is further adapted to provide acoustic field to said
3 fluid with selected characteristics to form a bubble proximate to said nucleation feature to impair
4 fluid flow in said microconduit.

1 110. The apparatus of claim 109, wherein said controller is adapted to signal said acoustic
2 source to cease to provide said acoustic field to cause said bubble to dissipate to remove said
3 impairment to fluid flow.

1 111. The apparatus of claim 78, wherein said at least one nucleation feature comprises a
2 plurality of nucleation features selectively positioned, and said apparatus further comprises a
3 movement mechanism adapted to time vary a relative position between said acoustic source and
4 said plurality of nucleation features to time vary said motion imparted to said fluid.

1 112. The apparatus of claim 78, wherein said fluid is contained in a microvessel having a
2 plurality of regions and contains a constituent initially located in a first of said plurality of
3 regions, said at least one nucleation feature includes a plurality of nucleation features, some of
4 which being positioned in each of said regions, and said acoustic source is further adapted to
5 provide said acoustic field selectively to each of said plurality of regions to cause said constituent
6 to flow from said first region through a remainder of said plurality of regions.

1 113. An apparatus for imparting motion to a fluid, said apparatus comprising,
2 an acoustic source adapted to generate an acoustic field, and
3 a controller adapted to control operation of said acoustic source, wherein
4 said apparatus is further adapted to direct said acoustic field selectively to at least one nucleation
5 feature located relative to said fluid to impart said motion to said fluid.

1 114. The apparatus of claim 113, wherein said acoustic source is further adapted to provide
2 said direction of said acoustic field, and to provide said acoustic field as a focussed acoustic field
3 to said at least one nucleation feature.

1 115. The apparatus of claim 113 further comprising, a positioning mechanism adapted adjust a
2 relative position between said acoustic source and said at least one nucleation feature, to bring
3 said at least one nucleation feature within a focal zone of said acoustic source.

1 116. The apparatus of claim 113 further comprising, a blocking mechanism adapted to block
2 said acoustic field from locations in said fluid not proximate to said at least one nucleation
3 feature.

1 117. The apparatus of claim 113, further comprising reflectors adapted to direct said acoustic
2 field to said at least one nucleation feature.

1 118. The apparatus of claim 113, wherein said fluid contacts a first surface and said at said
2 first surface includes said at least one nucleation feature.

1 119. The apparatus of claim 118, wherein said first surface is a surface of a microconduit.

1 120. The apparatus of claim 118, wherein said first surface is a surface of a microchamber.

1 121. The apparatus of claim 118, wherein said first surface is a surface containing one or more
2 active sites.

1 122. The apparatus of claim 118, wherein said at least one nucleation feature includes at least
2 one of a pit, crevice, defect, scratch, groove and ridge in said first surface.

1 123. The apparatus of claim 118, wherein said at least one nucleation feature includes at least
2 one of a hydrophobicity, wettability, and surface energy characteristic of said first surface.

1 124. The apparatus of claim 118, wherein said at least one nucleation feature includes a fabric.

1 125. The apparatus of claim 118, wherein said at least one nucleation feature includes an
2 electrochemically active site.

1 126. The apparatus of claim 118, wherein said fluid has a volume between about 0.1 pl and
2 about 10 ml.

1 127. The apparatus of claim 118, wherein said fluid has a volume between about 10 nl and
2 about 100 nl.

1 128. The apparatus of claim 113, wherein said at least one nucleation feature is suspended in
2 said fluid.

- 1 129. The apparatus of claim 113, wherein said fluid is contained in a microchamber.
- 1 130. The apparatus of claim 113, wherein said fluid is contained in a microconduit.
- 1 131. The apparatus of claim 128, wherein said nucleation feature includes at least one of a
2 bead, resin, microsphere and particle.
- 1 132. The apparatus of claim 113, wherein said acoustic source is further adapted to provide an
2 acoustic waveform having a frequency between about 10 kHz and about 100 MHz.
- 1 133. The apparatus of claim 113, wherein said acoustic source is further adapted to provide an
2 acoustic waveform having a frequency between about 100 kHz and about 10 MHz.
- 1 134. The apparatus of claim 113, wherein said acoustic source is further adapted to provide
2 said acoustic field at a power selected to promote bubble formation at said at least one nucleation
3 feature.
- 1 135. The apparatus of claim 113, wherein said acoustic source is further adapted to provide
2 said acoustic field at at least one of a duty cycle, duty cycles per burst, amplitude, frequency, time
3 variations in frequency, and time variations in amplitude selected to control cavitation of a
4 bubble at said at least one nucleation feature.
- 1 136. The apparatus of claim 113, wherein said acoustic field interacts with said at least one
2 nucleation feature to promote bubble formation in said fluid, and said apparatus further
3 comprises, cavitation sensors adapted to sense cavitation, and provide a feedback signal to said
4 controller, and said controller is further adapted to employ said feedback signal to control said
5 bubble formation.
- 1 137. The apparatus of claim 113, wherein said motion imparted to said fluid is of sufficient
2 magnitude to cause a mixing action in said fluid.
- 1 138. The apparatus of claim 113, wherein fluid is contained in a microdevice, and said
2 acoustic source is a component of said microdevice.
- 1 139. The apparatus of claim 138, wherein said acoustic source is positioned in direct contact
2 with said fluid.
- 1 140. The apparatus of claim 113, wherein said fluid is contained in a microdevice, and said
2 acoustic source is attached to an outer surface of said microdevice.

1 141. The apparatus of claim 113, wherein said apparatus is further adapted to direct said
2 acoustic field with sufficient specificity to promote mixing of only that portion of said fluid that
3 is proximate to said at least one nucleation feature.

1 142. The apparatus of claim 113, wherein said at least one nucleation feature is located relative
2 to an active site, and said apparatus is further adapted to direct said acoustic field with sufficient
3 specificity to promote mixing of a portion of said fluid proximate to said active site.

1 143. The apparatus of claim 113 further comprising, a positioning mechanism adapted to move
2 relative positions between said acoustic source and said at least one nucleation feature to alter
3 said motion imparted to said fluid.

1 144. The apparatus of claim 113, wherein said at least one nucleation feature is a plurality of
2 nucleation features located proximate to an array of active sites, and said apparatus is further
3 adapted to direct said acoustic field selected ones of said plurality of nucleation features to impart
4 a particular motion to fluid proximate to each of said array of active sites.

1 145. The apparatus of claim 113, wherein said acoustic source further comprises a plurality of
2 acoustic sources.

1 146. The apparatus of claim 113, wherein said at least one nucleation feature is a plurality of
2 nucleation features, and said apparatus is further adapted to direct said acoustic field at a
3 selective one of said plurality to effect a direction of said motion imparted to said fluid.

1 147. The apparatus of claim 119, wherein said at least one nucleation feature is located at said
2 first surface, and said apparatus is further adapted to direct said acoustic field to nucleation
3 feature to form a bubble proximate to said nucleation feature to impair fluid flow in said
4 microconduit.

1 148. The apparatus of claim 147, wherein said controller is adapted to signal said acoustic
2 source to cease to provide said acoustic field to cause said bubble to dissipate to remove said
3 impairment to fluid flow.

1 149. The apparatus of claim 113, wherein said at least one nucleation feature comprises a
2 plurality of nucleation features, and said apparatus further comprises a movement mechanism
3 adapted to time vary a relative position between said acoustic source and said plurality of
4 nucleation features to time vary said motion imparted to said fluid.

1 150. The apparatus of claim 113, wherein said fluid is contained in a microvessel having a
2 plurality of regions and contains a constituent initially located in a first of said plurality of
3 regions, said at least one nucleation feature includes a plurality of nucleation features, some of
4 which being positioned in each of said regions, and said apparatus is further adapted to direct
5 said acoustic field selectively to ones of said plurality of nucleation features in each of said
6 plurality of regions to cause said constituent to flow from said first region through a remainder of
7 said plurality of regions.